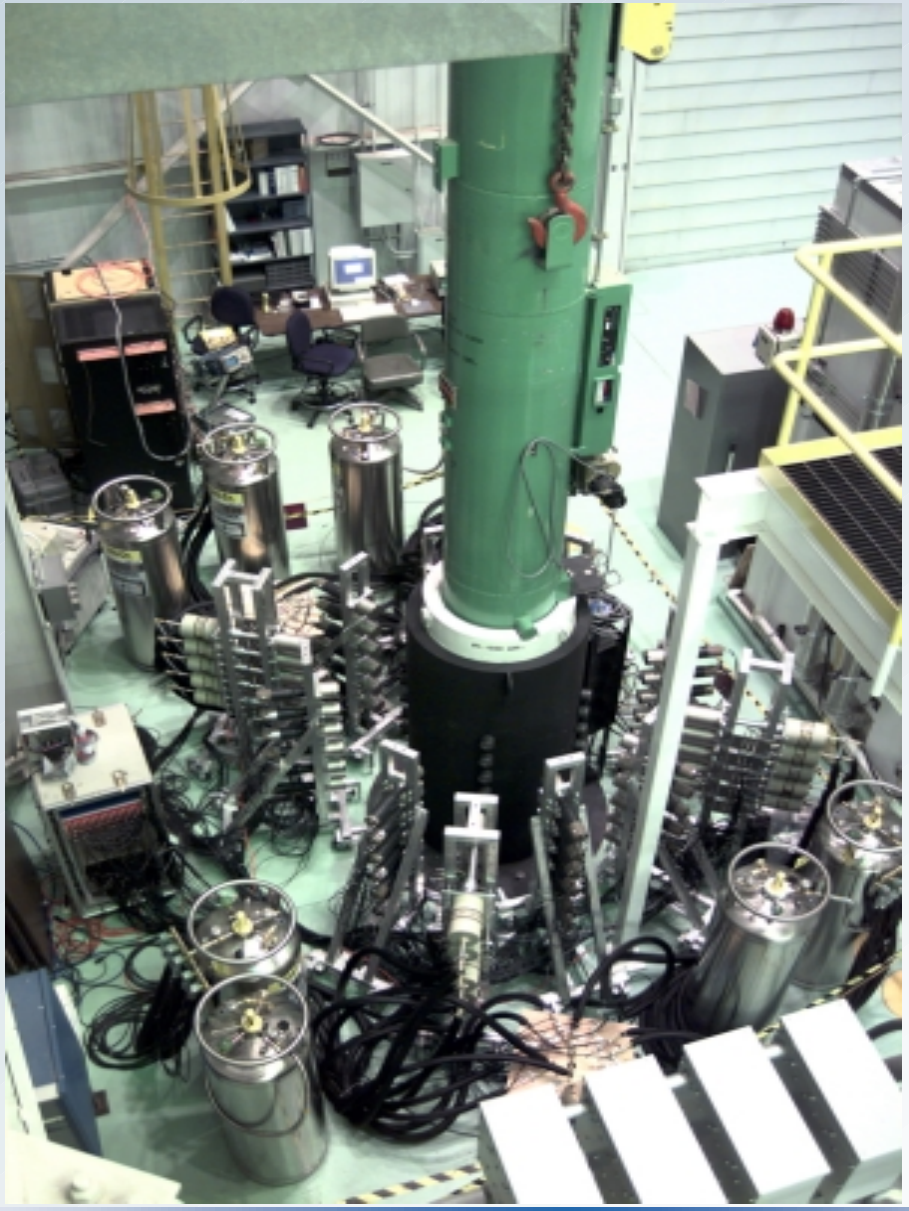
Multi-Detector Analysis System MDAS

William Hurt

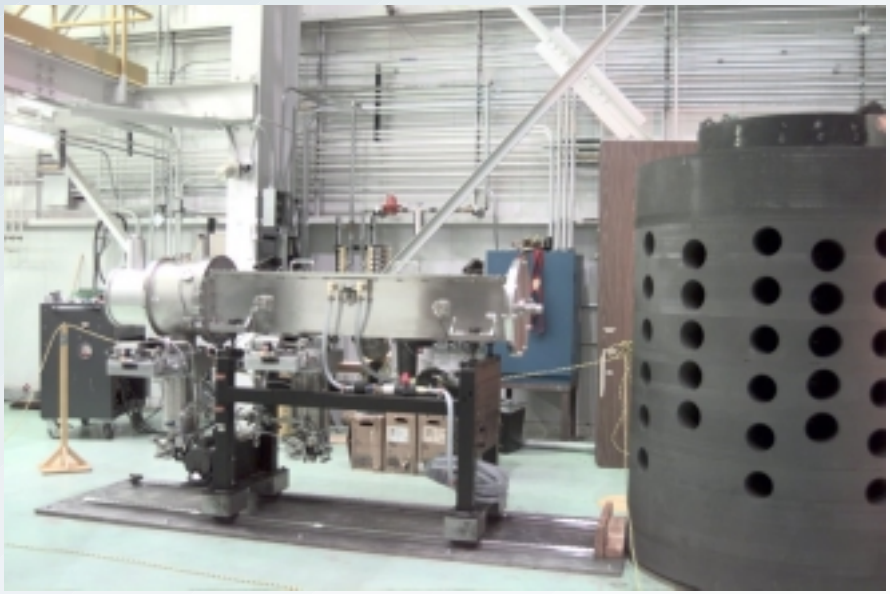
Providing for safe, efficient disposition of DOE spent nuclear fuel



Providing for safe, efficient disposition of DOE spent nuclear fuel

MDAS - a new approach to NDA

- MDAS technology
- Project status
- FY 2001 plans
- Future of MDAS



A multi-year project for developing a nondestructive assay technology

- Core research team of INEEL employees
- Research ongoing at INEEL, ORELA, IPNS
- This new system will satisfy several technical needs:
  - SNF characterization
  - RH-TRU waste characterization
  - Fissile material characterization

MDAS innovations are unique

- Fast coincidence
  - Timing is measured in nanoseconds
- Arrays of detectors
  - Work in high radiation fields
  - Suppress backgrounds
  - Handle high count rates
  - Provide better efficiency than large detector systems

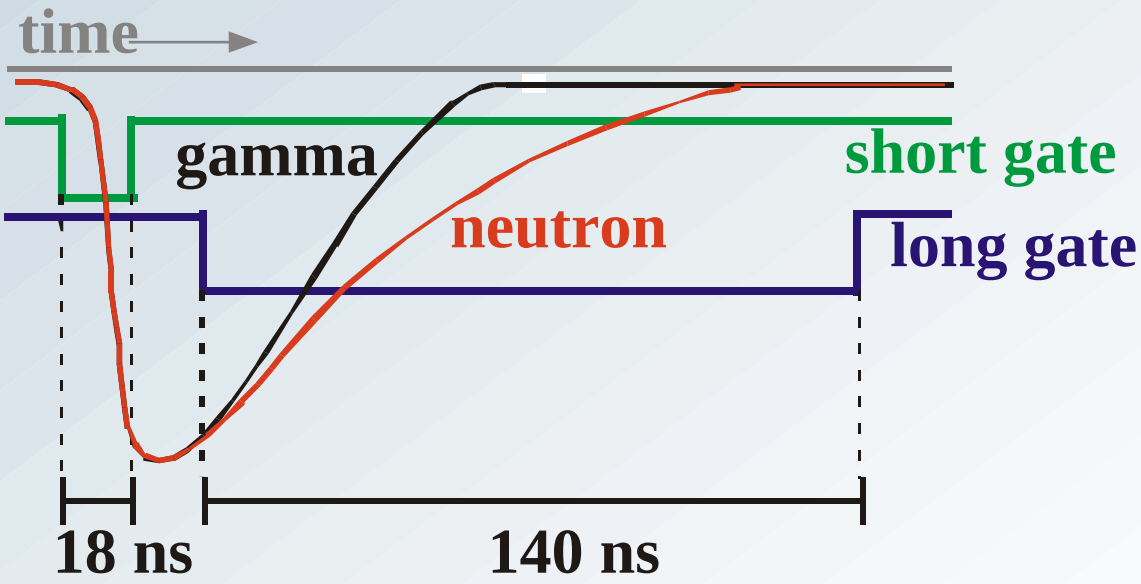
MDAS innovations are unique (continued)

- Improved pulse shape discrimination (PSD)
  - Result in better PSD to detect neutrons
- Does not require special calibration standards

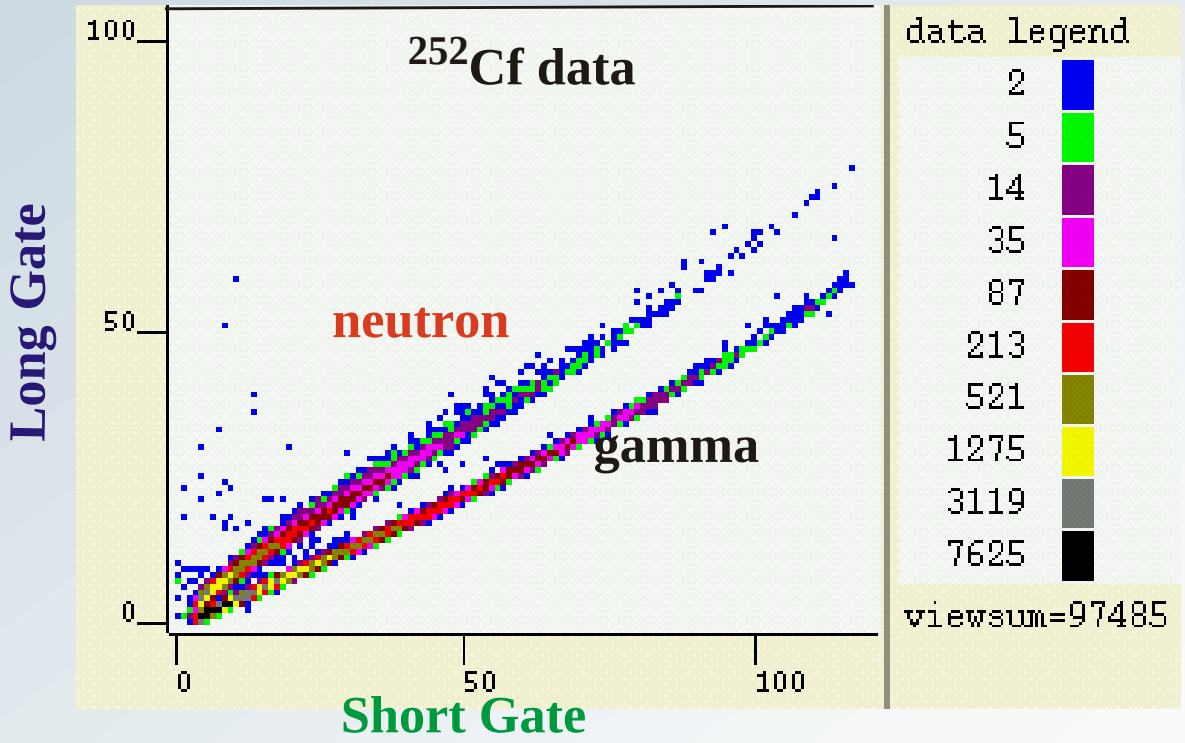
Multi-Detector Analysis System

- Fast coincidence
  - Within a given time window
  - About 50 ns window
  - Only coincident data are recorded by the system
  - Excellent for reducing random background
- Arrays of detectors
  - Gamma-ray coincidence (HpGe)
  - Neutron coincidence (Xylene)

Pulse Shape Discrimination



Pulse Shape Discrimination



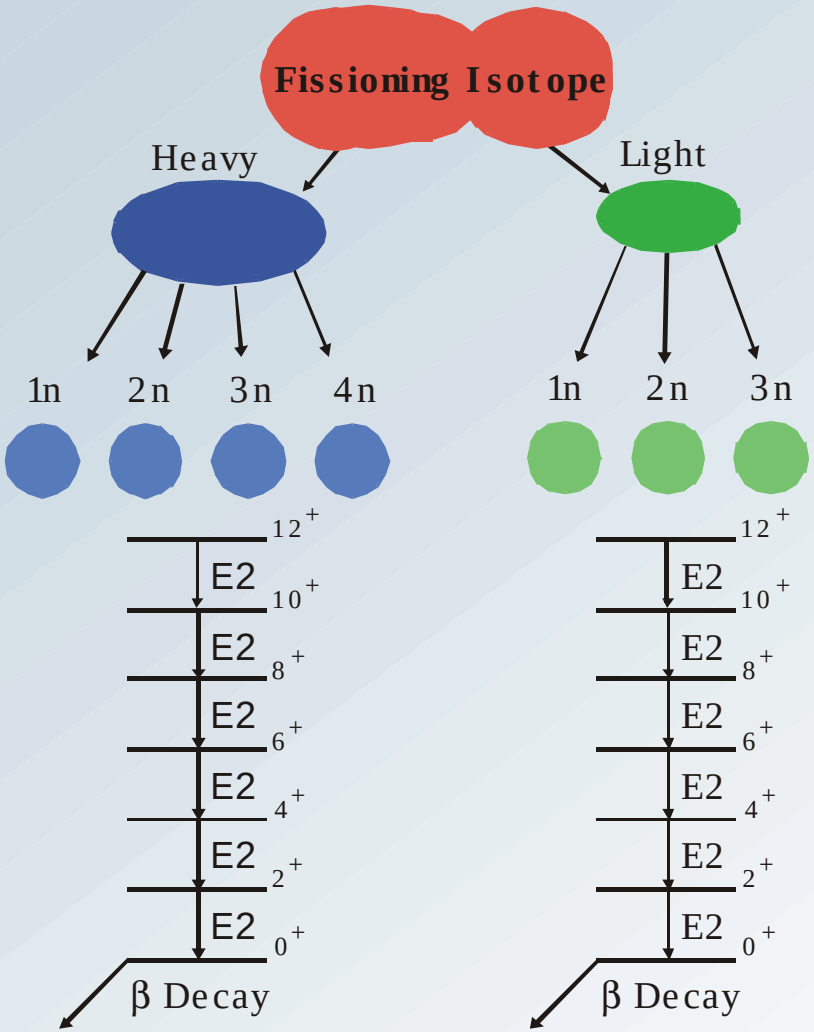
Basic Fission Process

- Correlate prompt radiations from fission events
- Fission products of interest
  - Light and heavy fragments
  - Some number of neutrons
  - Gamma-ray cascades from excited fragments

Basic Fission Process (continued)

- Standard view from beta decay studies:
  - Predominately low energy (300-400 keV) gamma-rays
- Prompt fission studies:
  - Show strong gamma emissions between 1 and 5 MeV

Fission and Decay Process



Prompt radiations

- 10-16 seconds

Fission products are

- two fragments
- zero to 10 neutrons
- several γ rays

Conservation Rules

$Z_F = Z_H + Z_L$ Z Conservation

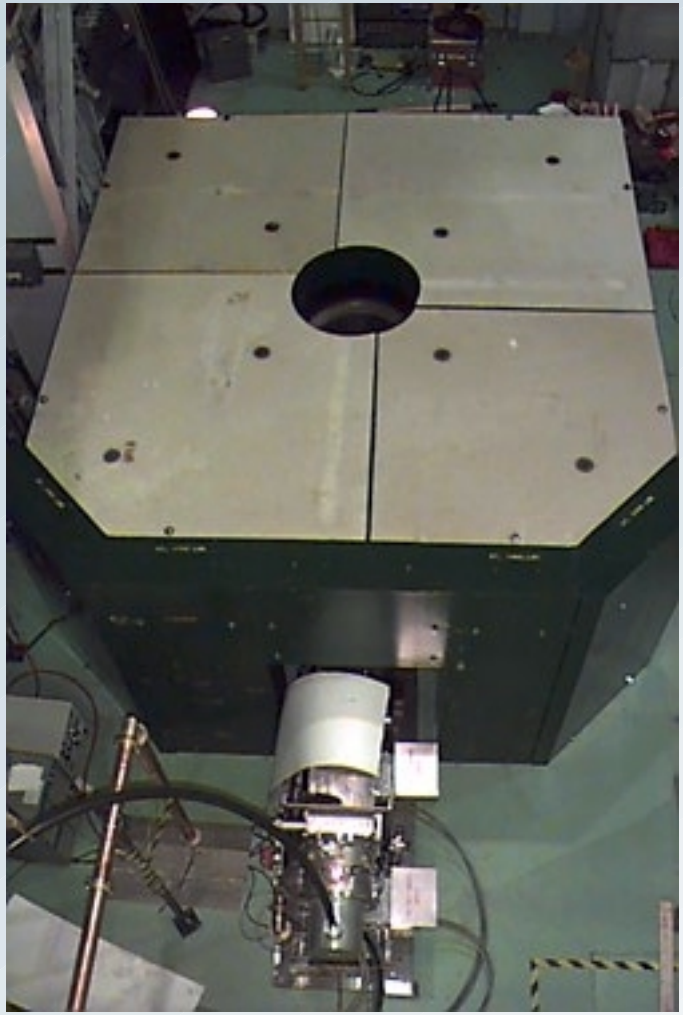
$A_F = A_H + A_L + xn$ A Conservation

Fissioning Isotope	Light-mass Fragment Paired with ^{134}Te					
	N=0	N=1	N=2	N=3	N=4	N=5
^{235}U	^{102}Zr	^{101}Zr	^{100}Zr	^{99}Zr	^{98}Zr	^{97}Zr
^{238}U	^{105}Zr	^{104}Zr	^{103}Zr	^{102}Zr	^{101}Zr	^{100}Zr
^{239}Pu	^{106}Mo	^{105}Mo	^{104}Mo	^{103}Mo	^{102}Mo	^{101}Mo
$^{240}Pu^*$	^{106}Mo	^{105}Mo	^{104}Mo	^{103}Mo	^{102}Mo	^{101}Mo
^{241}Am	^{108}Tc	^{107}Tc	^{106}Tc	^{105}Tc	^{104}Tc	^{103}Tc
$^{242}Pu^*$	^{108}Mo	^{107}Mo	^{106}Mo	^{105}Mo	^{104}Mo	^{103}Mo
$^{252}Cf^*$	^{118}Pd	^{117}Pd	^{116}Pd	^{115}Pd	^{114}Pd	^{113}Pd

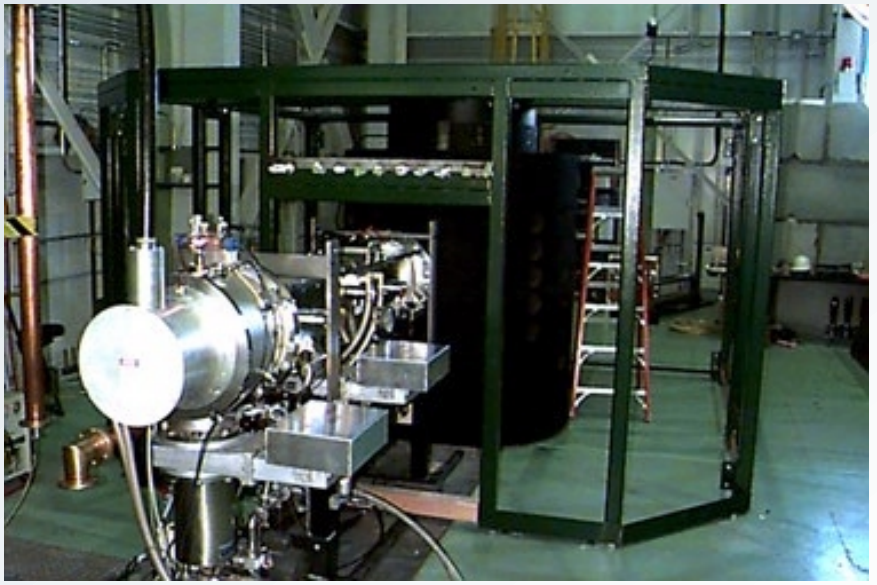
Project Status - FY 2000

Installation and operability testing of the neutron generator - February 2000

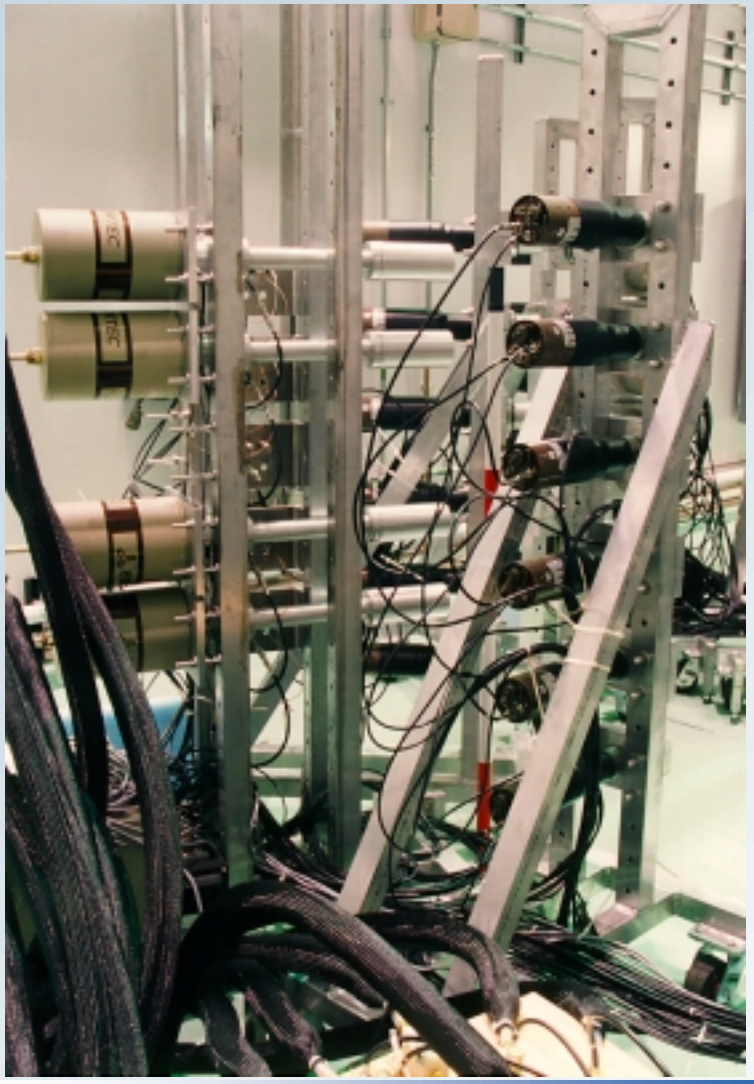
Project Status - FY 2000



Primary shielding installed - July 2000



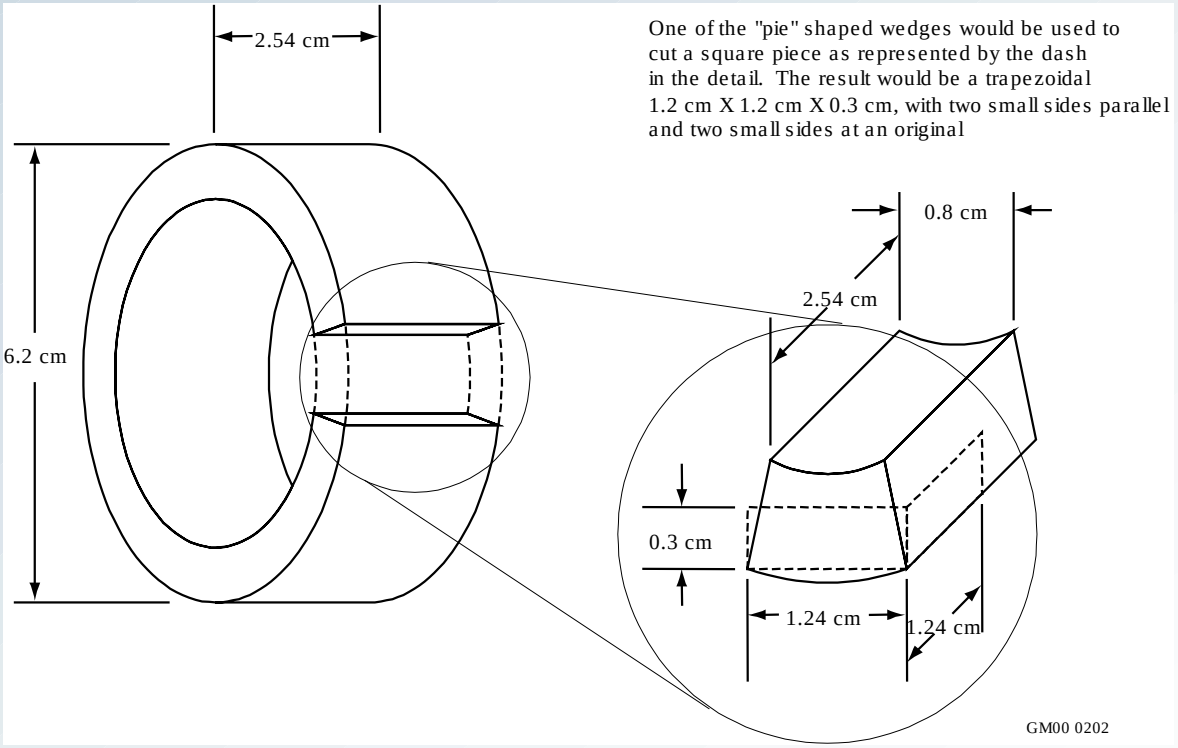
Project Status - FY 2000



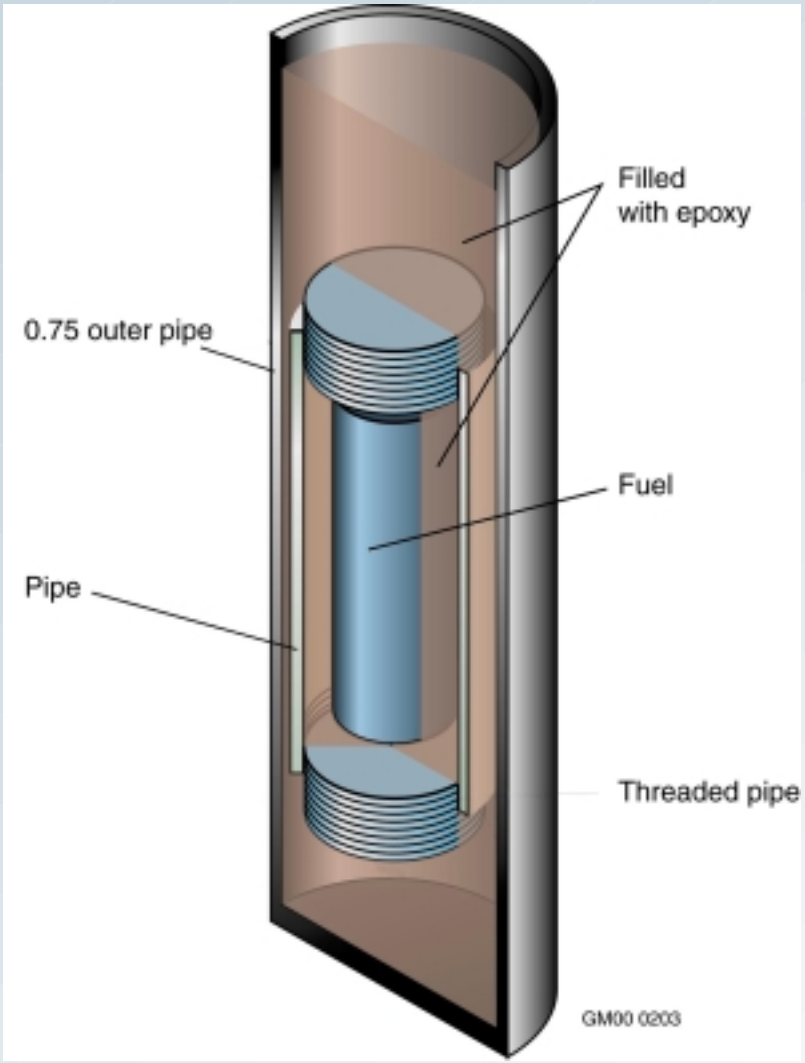
- Set up and calibrated detector arrays and other instrumentation
- Continued developing GUI software

Project Status - FY 2000

Initiated measurement of SNF at IPNS



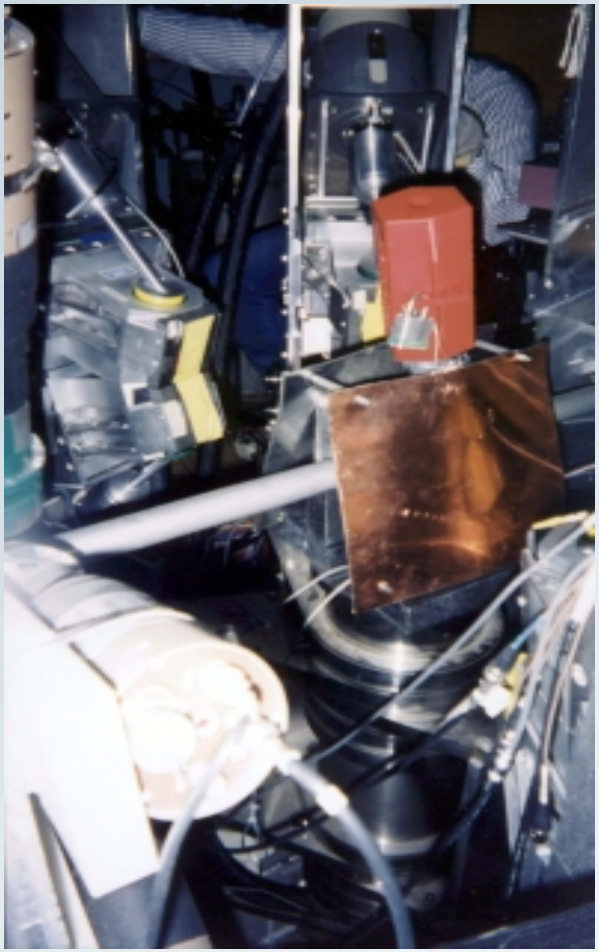
Project Status - FY 2000



- Initiated measurement of SNF at IPNS
  - Encapsulated fuel sample
  - Inner tube filled with epoxy
  - 0.75-in. outer diameter stainless steel tube
  - One end welded closed

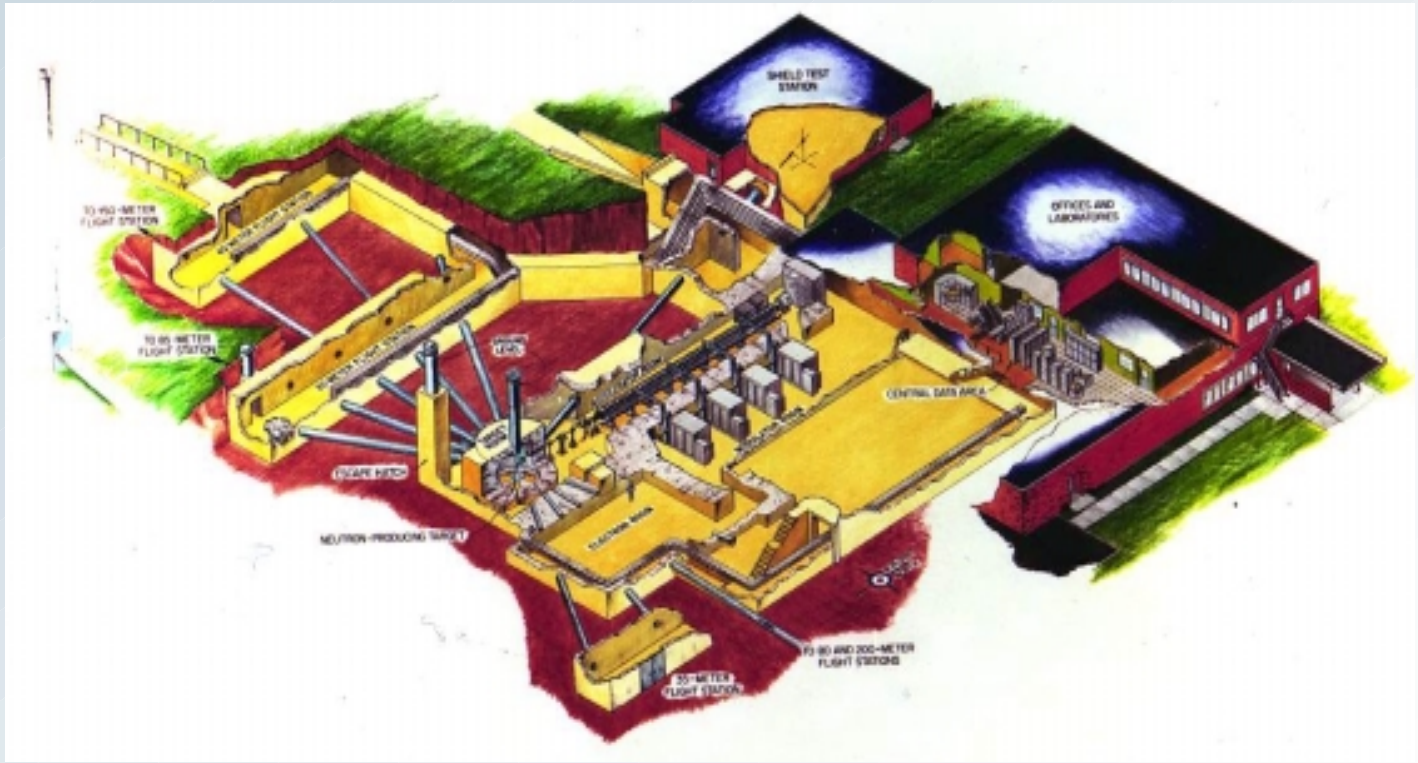
Project Status - FY 2000

Initiated measurement of SNF at IPNS



Project Plans for FY 2001

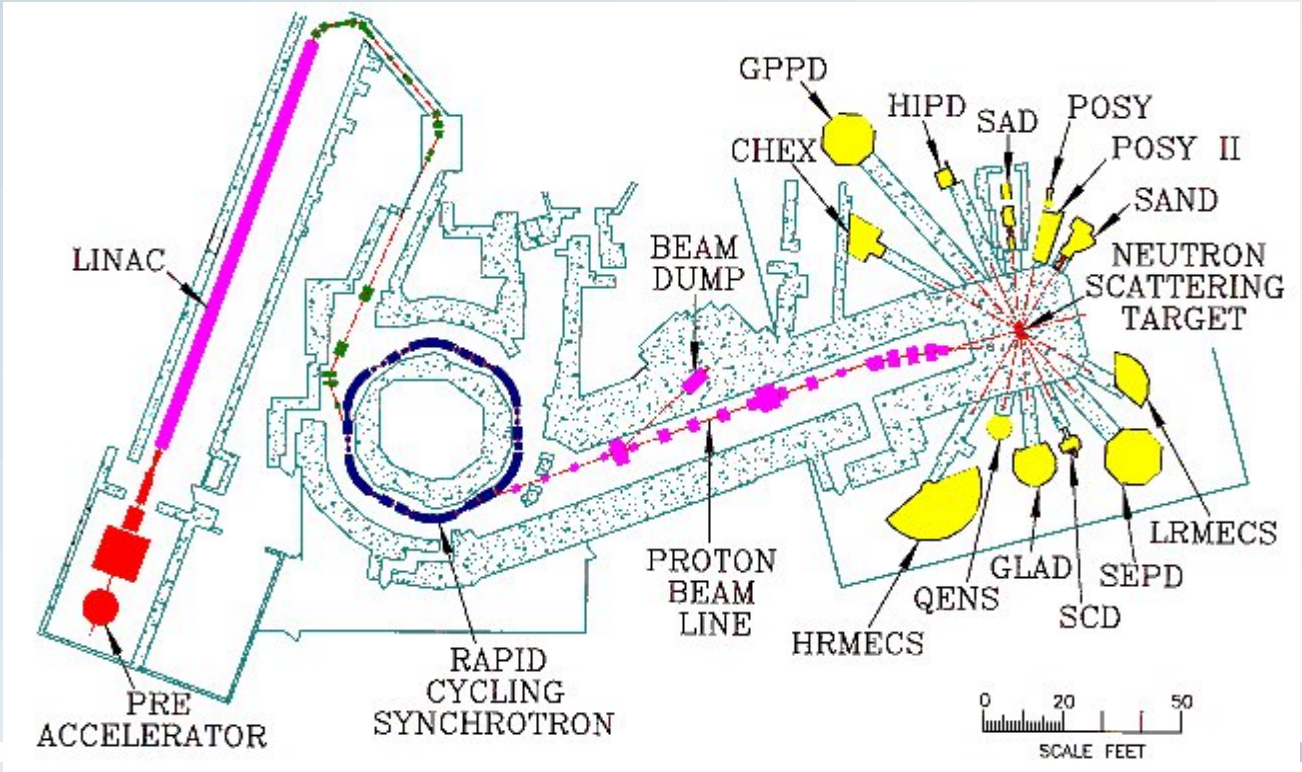
- Focus on applied research at ORELA
  - Measurements on SNF/FH-TRU surrogates



NSNFP
National Spent Nuclear Fuel Program

Project Plans for FY 2001

- Focus on measurements at IPNS
  - Basic physics experiments
  - Continue measurement/data collection ^{233}U, ^{235}U, & ^{237} Np



Project Plans for FY 2001

- Focus on data analysis at INEEL
  - Fission fragment yields for isotopes of interest
  - Selection of partner pairs
  - Supplies data for algorithm development

MDAS is a key technology for SNF Programs

- Developing a means -- independent of process knowledge and item records -- to provide characterization information on SNF

MDAS is a key technology for SNF Programs (continued)

- Early results indicate MDAS can provide needed radiological information
  - Total fissile mass
  - Fissile isotopics
  - Specific fission products
  - Radionuclide content
- Using actual measurements

The Future of MDAS Technology

- Develop an NDA prototype
- Explore options for application
- Define potential customer base
- Engage commercial partners
- Modify and refine technology
- Deploy functional system